Rockwell International

MODEL 203
METRIC CONVERTER
SERVICE AND PARTS MANUAL

1000-0426

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UNICOM SYSTEMS, ROCKWELL INTERNATIONAL

SERVICE & PARTS MANUAL

MODEL 203

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I. INTRODUCTION

This manual is provided to enable the service technician to diagnose and repair the Metric Converter calculator.

The Metric Converter is an eight digit, hand-held calculator which performs addition, subtraction, multiplication, and division functions. It can also be used for length, area, volume, weight, liquid, temperature, and programmable conversions.

II. OPERATION

MACHINE FUNCTIONS

The Model 203 performs the four basic functions of arithmetic; in addition, there are the "second" conversion functions. All entries are in algebraic format, and all operations are in decimal format with numbers represented in sign and magnitude form. The magnitude of numbers handled include all numbers from 10^{-7} to 10^{8}. Numbers in excess of 10^{8} will cause an overflow condition and the decimal point will be displayed 8 digits to the left of its correct position. Features include automatic constant, chain calculations, two fully addressable memories, floating or fixed output, U.S. or Imperial measurements, and land or nautical measurements.

KEYBOARD

The keyboard consists of 20 momentary contact key switches, divided into data entry keys, arithmetic operation keys, command keys, memory keys, conversion keys, and static switches.

DATA KEYS

The data keys consist of the digit entry keys [0 - 9] and the decimal point key. Any number with eight or fewer significant whole number digits, or any number with seven or fewer significant decimal digits may be entered. All entries in excess of eight whole numbers or seven decimal digits will not be accepted. The decimal point key will be accepted the first time it is depressed during any number entry from the keyboard.

ARITHMETIC OPERATION KEYS

The arithmetic operation keys include the addition [+], subtraction [-], multiplication [x], division [÷], the equal [=] key, and the fraction conversion [A/O] key.

ADDITION KEY [+]

Depressing the [+] key will perform the previously established condition (if any), and then prepare the 203 to add the next entry on the keyboard to the number in the display upon depression of another operation key.

SUBTRACTION KEY [-]

Depressing the [-] key performs the same functions as the [+] key except that subtraction takes place.

MULTIPLICATION KEY [x]

Depressing the [x] key performs the same functions as the [+] key except that multiplication takes place.

DIVISION KEY [÷]

Depressing the [÷] key performs the same functions as the [+] key except that division takes place.

EQUAL KEY [=]

Depressing the [=] key performs the previously established condition, establishes a constant, then terminates the calculation. The constant number will be the last entry made before depressing the [=] key. The constant function will be the last function depressed before depressing the [=] key.

FRACTION CONVERSION KEY [A/0]

Note: Before using this function, except in chain calculations, depress the [C] key twice.

Depressing this key allows the entry of fractions and mixed numbers. To convert a fraction (eg. 2/3) to a decimal number, enter 2, depress [A/0], enter 3, depress [=]. For mixed numbers (eg. 8 3/4), enter 8, depress [A/0], enter 3, depress [A/0], enter 4, depress [=].

The [A/0] key can be used in chained calculations by depressing any other function key instead of the [=] key. The [A/0] operation is terminated by depressing any key other than [0 - 9], [·], [M].

COMMAND KEYS

The command keys include the clear [C] key, memory select [M] key and conversion [CONV] key.

CLEAR KEY [C]

Depressing the [C] key immediately after a digit entry, but before depressing a function key, will clear the entry but will not affect the contents of the working register.

Depressing the [C] key after depressing a function key or after clearing an entry will reset any calculating mode and clear all registers except the memories.

Depressing the [C] key during an overflow condition will reset the error condition. The resulting number displayed will be correct if multiplied by 10^8, and can be used in further calculations.

Depressing the [C] key once will clear the overflow condition but will not clear the display or any operating conditions or modes. Depressing the [C] key twice will clear the display and reset all modes of operation. The memories will not be cleared.

MEMORY KEY [M]

All memory operations are initiated with the depression of this key. Memory 1 is automatically selected when the calculator is turned on. The depression of the [M] key followed by the number [1] or [2] will select one of the two memories. Depressing [M] [1] will select memory 1 and depressing [M] [2] will select memory 2. Once a memory is selected, subsequent memory operations will apply to that memory until the other memory is selected.

To add 25 to the selected memory: Enter 25, depress [M] (M+). 25 will be added to the value in that memory. The display will not change.

To subtract from a memory: Enter the number to be subtracted and depress [M] (M-). The display will not change.

To display the contents of a memory: Depress [M] (MR). The contents will be displayed but the memory is not affected.

To clear the contents of a selected memory: Depress [M] (MC). The memory will be cleared but the display will be be affected.

NOTE: Symbols or numbers in brackets "[ ]" denote the function printed on a key. Symbols in parentheses "( )" denote the function which is printed above or beside a key.

EXPLANATION OF SYMBOLS IN PARENTHESES

A - Used with programmable conversion.
B - Used with programmable conversion.
C^{O} - Degrees Centigrade.
F^{O} - Degrees Fahrenheit.
FEET - Feet
FL OZ - Fluid Ounces
GAL - Gallons
GM - Grams
INCH - Inches
K→ - Store programmable conversion constant.
KG - Kilograms
KM - Kilometers
LB - Pounds
LIT - Liters
M - Meters
M+ - Add into Memory
M- - Subtract from Memory
MC - Memory Clear
MM - Millimeters
MILE - Miles
MR - Memory Recall
OZ - Ounces
QT - Quarts
YARD - Yards

CONVERSION KEY [$^{CO}_{NV}$]

The [$^{CO}_{NV}$] key is used to set up the operation that converts the number in the display from one unit of measure to another. The first key depressed after [$^{CO}_{NV}$] specifies the unit of measure being entered, and the second key specifies the unit of measure to which it is being converted.

To convert linear measure to square measure, repeat the conversion operation using the answer given for linear measure.

To convert square measure to cubic measure, repeat the conversion operation using the answer given for square measure.

Conversion constants contained in the Model 203:

Calculator Nomenclature	Units of Mass
(kg)	1 kilogram = 2.2Ø46226 pounds (avop.)
(kg)	1 kilogram = 1ØØØ. grams
(lb)	1 pound (avop.) = 16. ounces (avop.)
(oz)	1 ounce (avop.) = 28.349523 grams
	Units of Length
(mile)	1 nautical mile (Int.) = 1.15Ø7795 mile (statute)
(mile)	1 mile (statute) = 1.6Ø9344 kilometers
(mile)	1 mile (statute) = 176Ø. yards
(km)	1 kilometer = 1ØØØ. meters
(m)	1 meter = 1ØØØ. millimeters
(yd)	1 yard = Ø.9144 meters
(yd)	1 yard = 3. feet
(ft)	1 foot = 12. inches
(in)	1 inch = 25.4 millimeters
	Units of Volume, Liquid Measure
(gal)	1 gallon (U.K. liquid) = 1.2ØØ95Ø3 gallon (U.S. liquid)
(gal)	1 gallon (U.K. liquid) = 4. quart (U.K. liquid)
(gal)	1 gallon (U.S. liquid) = 3.33Ø6957 quart (U.K. liquid)
(gal)	1 gallon (U.S. liquid) = 4. quart (U.S. liquid)

Units of Volume, Liquid Measure

(qt)	1 quart (U.K. liquid) = 1.1365229 liters
(qt)	1 quart (U.K. liquid) = 40. ounces (U.K. liquid)
(qt)	1 quart (U.S. liquid) = 32. ounces (U.S. liquid)
(lit)	1 liter = 1.0566882 quarts (U.S. liquid)
(fl oz)	1 ounce (U.S. Liquid) = 1.0408424 ounces (U.K. liquid)

STATIC SWITCHES

U.S./IMP: During conversion mode the setting of this switch determines whether the liquid measurements, (FL OZ), (QT), and (GAL), are to be interpreted as U.S. liquid measurements (units of measure used in the United States), or Imperial measurements (units of measure used in England and Canada). The position of this switch may be changed at any time. For example, if converting from U.S. gallons to Imperial gallons, enter the number of gallons, with the switch in U.S. position, depress [$^{CO}_{NV}$] (GAL), put switch in IMP position and depress (GAL) again. The display will show the equivalent Imperial gallons.

F/2: The position of this switch controls the decimal format of answers. With the switch in the F position the final answer will be left in full floating format. With the switch in the 2 position the result is rounded to 2 decimal places.

LAND/NAUT: The setting of this switch determines whether the (MILE) key is to be interpreted as land (statute) miles or nautical miles. The switch position may be changed at any time. For example, if converting from statute to nautical miles, enter number of miles, put switch in LAND position, depress [$^{CO}_{NV}$] (MILE), put switch in NAUT position and depress (MILE) again. The equivalent in nautical miles will be displayed.

PROGRAMMED CONVERSIONS

Conversions can also be made to units that do not have a built-in constant by using the programmable conversion function. The conversion factor is set up by entering it and depressing [$^{CO}_{NV}$], (K→). This stores the factor in a special memory. It will be maintained until changed or until the cal ulator is turned off. The conversions utilizing this factor are performed using the (A) and (B) keys.

To convert from the type of measure of the stored constant to another type of measure, enter the number to be converted, depress [$^{CO}_{NV}$], (A), and (B).

To convert from some other type of measure to the type of measure of the stored constant, enter the number to be converted, depress [$^{CO}_{NV}$], (B), and (A).

OVERFLOW CONDITIONS

An overflow condition will cause the overflow indicator to light and the display to be filled with 8 digits, each followed by a decimal point, e.g., Ø.Ø.Ø.1.2.3.4.5. Error conditions are caused by the following operations:

(1) Any operation with a result larger than $1Ø^8-1$ (which equals 99,999,999).
(2) Division by zero.
(3) Any operation resulting in a number larger than 10^8-1 in memory.
(4) Conversions between units not of the same type (e.g., converting feet to gallons).

During an overflow condition the calculator becomes inoperative until the first depression of the [C] key is made.

WRAP-AROUND DECIMAL POINT

When an overflow condition exists as in conditions 1 and 3, the result displayed (condition 1) or in memory (condition 3) after depressing [C] will be the 8 most significant digits. The decimal point will be displayed 8 digits to the left of its correct position. Multiply it by $1Ø^8$ to get the correct answer. (e.g., 123456 x 123456 = 1.5.2.4.1.3.8.3 Depress [C] to read 152.41383. The correct number is 152.41383. x $1Ø^8$, or 1524138ØØØ.)

In condition 3, the overflowed value is in the memory. After depressing [C] the value in the display may be used for further calculations. However, upon recalling the memory the decimal point must be moved 8 places to the right to be correct.

III. CIRCUIT DESCRIPTIONS

SPECIFICATIONS

Operating Voltage	4 to 7 VDC
Operating Current	80 - 120 ma @ 6V

BLOCK DIAGRAM

Figure 1 is a block diagram of the main segments of the calculator system. The keyboard is the manual control input device used to enter data, direct operational sequences, and provide a calculator clear function.

The calculator chip is a fully decoded, parallel-out, 8-digit calculator chip and contains the Central Processing Unit (CPU), display driver, logic circuit, clock, Read-Only Memory (ROM), and Random Access Memory (RAM).

The display unit presents a readout of the processed arithmetic and displays the data stored in the input/display register. Eight whole number digits and a decimal point may be displayed or seven digits for numbers less than one. A separate overflow indicator is provided at the upper left of the display and negative number indicator is provided at the upper right of the display.

The power supply is a dc to dc converter and distributes the required voltage to the system.

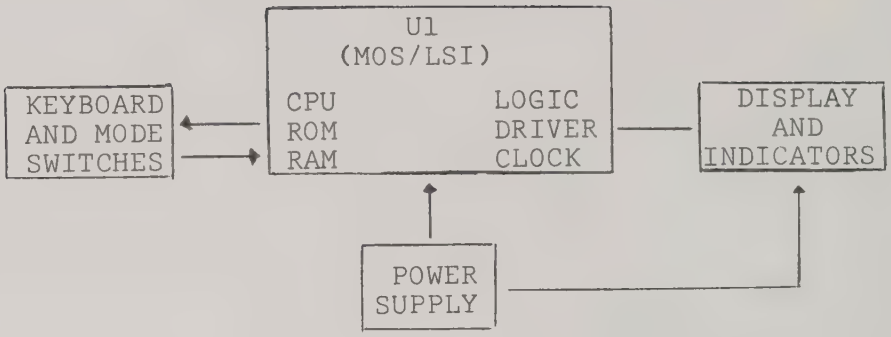


Figure 1

SYSTEM OPERATION

POWER-ON RESET

The application of power to the system automatically clears all calculator electronics including memory. A zero and decimal point will be displayed at the right most position of the Digitron display.

The power-on reset circuitry is external to the MOS/LSI chip. An R-C network (R1, C1) insures that the voltage at PØ (U1-11) stays less negative than -3V until V_{DD} (U1-6) has reached its steady state value (-14.2 to -15.8 VDC). A diode CR2 is connected across R1 to permit rapid discharge of C1 when the calculator is turned off. See Figure 12.

The waveforms for the V_{DD} (U1-6) and PØ (U1-11) with respect to chip ground are typically as shown in Figure 2.

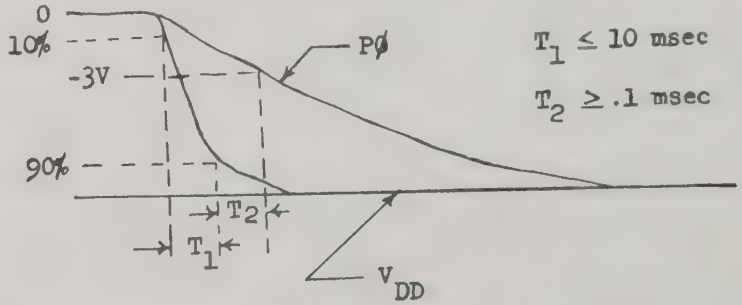


Figure 2

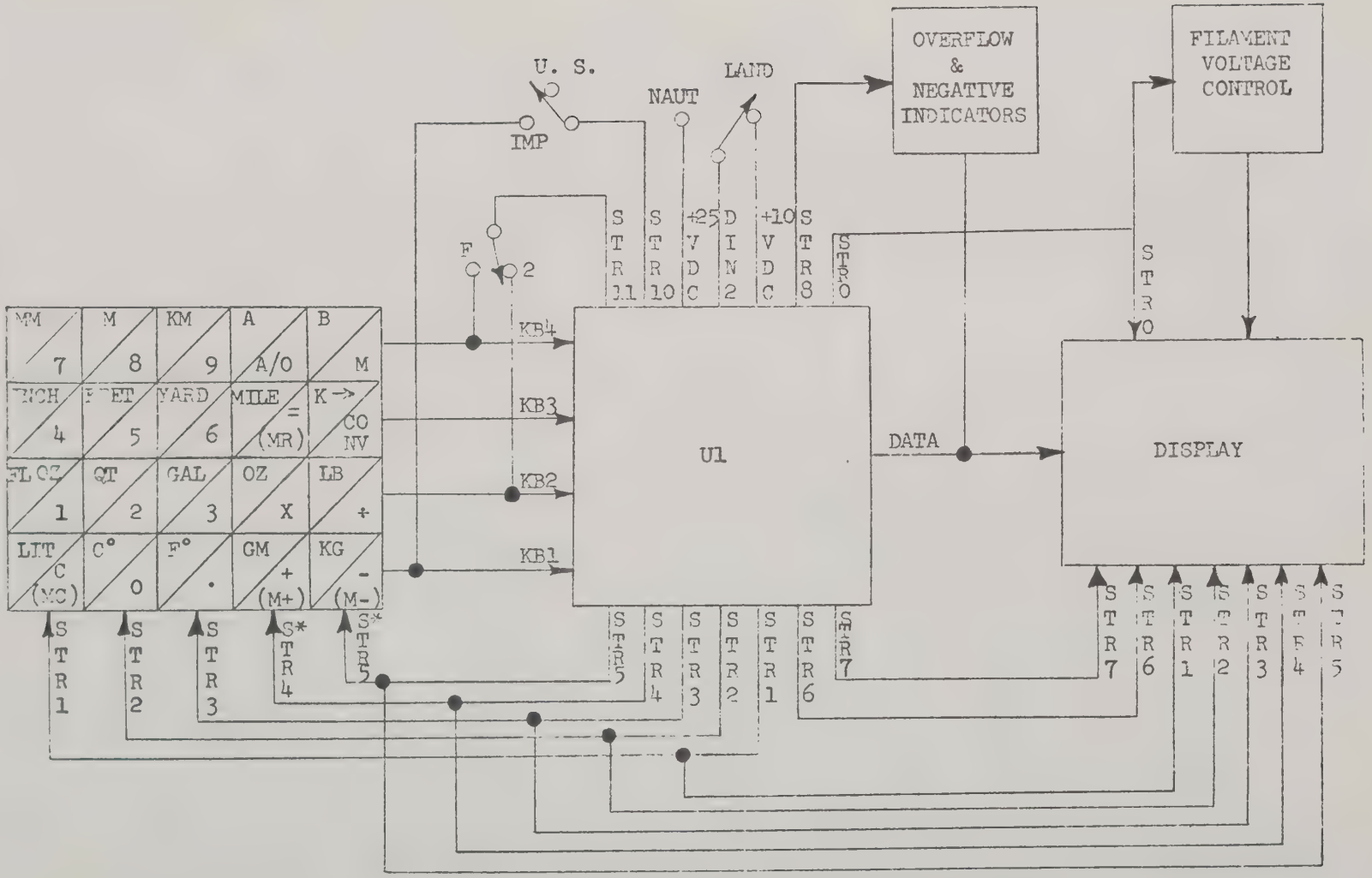
DATA ENTRY

Figure 3 shows a functional block diagram of the calculator's operation. Note that the outputs from the keyboard form a five by four matrix with twenty possible output configurations. The keyboard is scanned sequentially by the strobe signals to determine if a key is depressed. The mode switches are also scanned sequentially by strobe signals, except for the LAND/NAUT switch which connects discrete input 2 (DIN 2) to either +10 volts dc or +25 volts dc. When a key is depressed or a mode switch position is changed, the switch closure connects one of the strobe outputs to one of the keyboard or mode switch reply lines. Data is entered (up to 8 digits or 7 decimals) until one of the command function keys is depressed. The data stored in the input/display register is fed in parallel to the display driver portion of the calculator chip where it is translated from its parallel form to drive signals for the Digitron display.

KEYBOARD

The keyboard assembly is housed in the chassis assembly and is located below the printed wiring board. Connections from the keyboard to the printed wiring board are made via color coded wires. For wire assignments see Table 1.

It is not necessary to remove the wires from the keyboard or from the printed wiring board to check the performance of the mechanical closures; however, care should be exercised when lifting the keyboard assembly away from the chassis so as not to break any of the connections. Contact resistance is less than 1000 ohms and is generally near 0 ohm.



*STR4 and STR5 are labeled STR6 and STR7, respectively, on the keyboard.

Figure 3

POWER SUPPLY

The power supply is a flyback dc to dc converter. The power supply provides output voltage regulation for variations in input voltage and output load. The power supply is capable of supplying 200 mw of power at +25V over an input voltage range from 4.0 to 7.0 volts dc.

The power supply system consists of a variable frequency oscillator, a transistor switch, a coil, and a rectifier-capacitor filter. Feedback is provided through two zener diodes which also control the nominal value of the output voltage. Energy transfer from the input voltage source is accomplished through the transistor-coil combination. The oscillator drives the transistor switch providing a constant on-time with a variable off-time which is proportional to the input voltage and output load. As the input voltage increases or the output load decreases, the frequency at which the transistor switch closes decreases, the on-time remaining constant. The frequency increases for opposite changes in the input voltage or output load.

The power supply circuit is shown in Figure 12. Z1 is the variable frequency oscillator. C4 is part of the oscillator circuit. C2 is a decoupling capacitor. R7 and C3 control the oscillator and set the on-time of the switch. C5 serves as a slow-down capacitor at power turn-on. Q1 is the output switch. L1 is the flyback coil. Zener diodes VR1 and VR2 are the feedback devices for the closed loop. CR3 is a power supply diode. C6 is a filter. Q2 is an emitter follower and supplies +10 volts to the MOS/LSI chip.

During normal operation, the converter should require less than 95 ma at 6.Ø volts at the input. With 6.Ø ± Ø.1 volts applied between GRD and -6V, the voltage between +25 and GRD should be between 23.36 and 26.36 volts dc. The voltage between +25 and +1Ø should be between 14.2 and 15.8 volts dc. The waveform at the collector of Q1 is shown in Figure 12 for a 6-volt input.

OVERFLOW AND NEGATIVE INDICATORS

The overflow and negative indicator circuitry is shown in Figure 12. The overflow indicator also indicates an error condition. The circuit is a typical "AND" circuit. Transistor Q5 is associated with the negative indicator and transistor Q6 is associated with the overflow indicator. Transistor Q3 controls both circuits. When Segment 7 and Strobe 8 are both true, the negative indicator lights. Likewise, when Segment 6 and Strobe 8 are both true, the overflow indicator lights. Both indicator lamps are light emitting diodes and are located on the printed wiring board.

DIGITRON TUBE DISPLAY

The display is comprised of eight Digitron tubes in a single case, a partial schematic of which is shown in Figure 4. Each tube has eight plates, one each for the seven segments of the numeric display and one for the decimal point. The plates are controlled by Segments 1 thru 7 and DP. The grid of each tube is controlled by Strobes Ø thru 7. The filament of each tube is controlled by a drive circuit (Figure 12), which is used to control the filament voltage.

DIGITRON OPERATION

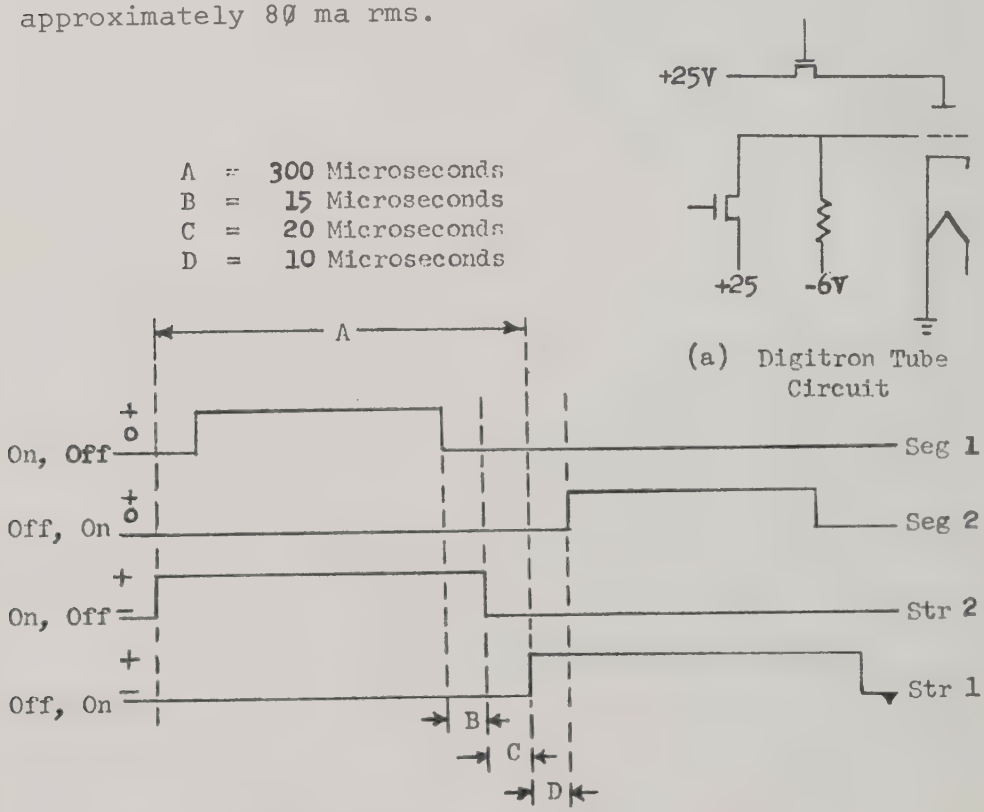
The strobe drivers are completely multiplexed with a duty cycle of 1 out of 9. The strobe drivers are sequenced by the internal clock and no two strobe drivers are on at the same time. This strobe separation is required for inter-digit blanking. The strobe drives to MOS ground when driving a specified digit. Because the MOS ground is at a +25 volt potential, +25 volts is delivered to the grid of the digit when that digit is being driven. Each digit has seven segments and a decimal point. Segment 1 of each digit is common as is segment 2, segment 3, etc. Segment outputs are updated each strobe time.

The display operates as a simple "AND" circuit. If both the strobe output and the segment output are true, the segment lights. Because the strobe sequencing is rapid and there is some retentivity in the Digitron tubes, all the activated digits appear to be lighted at the same time.

When strobe 1 is on, a +25 volt potential is placed on the grid of digit 1. If segments a, b, and c of digit 1 are on, a +25 volt potential is placed on the plates of the Digitron tube. These plates are actually the segments themselves. Electrons now flow from the filament to the plates and the number "7" lights in digit 1. When strobe 1 turns off, strobe 2 turns on and the segment outputs are updated. Now those segments of digit 2 that have a +25 volt potential on them light up. This strobe sequencing continues through the remaining digits and begins again with digit 1.

The output drivers on the strobes and segments are open drain MOS devices with a typical on resistance of less than 700 ohms to ground. A load resistor is placed externally to the chip on the strobe lines as part of the display interface. Figure 4 depicts typical segment and strobe timing and shows a schematic of a Digitron tube circuit.

The Digitron tube is rated at approximately 80 ma rms and 1.6 volts rms. Since only 6 volts is available, a transistor driver triggered by a strobe pulse from the MOS/LSI circuit is used to generate the necessary voltage. Figure 12 shows a schematic of this circuit. Strobe 0 turns Q4 on at a 1/9 duty cycle. CR10, CR11 and R21 control the peak current to maintain the overall filament current at approximately 80 ma rms.



(a) Digitron Tube Circuit

(b) Typical Segment and Strobe Timing

Figure 4

IV. PRECAUTIONS & SAFETY

PRECAUTIONS

The chips (MOS/LSI devices) are very susceptible to the high static electricity frequently found in service areas. It is, therefore, mandatory that the following precautions be taken in handling these devices:

1. Devices should not be removed from their protective handling/shipping container until ready to use.
2. All work surfaces, handling tweezers and magnets, soldering iron tips, solder pots, and all other equipment which comes in contact with the device must be electrically grounded.
3. Large plastic surfaces act as static accumulators and must be avoided.
4. Before handling a device, the user must momentarily touch a grounded metal object to remove the static charge.
5. Smocks made of nylon and other synthetic materials which generate static charges must not be worn.
6. The device must be handled with grounded tweezers, magnets, or similar tools. Always pick the device up by the plastic body, never by the leads.

SAFETY

All electrical test equipment should be grounded to eliminate potential danger to personnel.

V. DIAGNOSTIC TEST

To determine the failure modes, the following test should be performed to the extent possible before disassembling the calculator. Any discrepancy should be noted and appropriate action taken per the Troubleshooting Table.

a. Turn the calculator on. Verify that the battery output voltage is between 4.Ø and 5.5 volts.

b. Multiply -98765432 x 9 = -8.8.8.8.8.8.8.8. All segments of the digits and all decimal points should glow. The display should be uniformly bright. The OVF and MINUS indicators should be visible.

c. Clear the calculator. Enter the number 8.8888888. While entering the number, verify that all decimal points are operative (only one decimal point should be on at one time).

d. Perform the following test problem. The left column indicates the action to be taken. The right column indicates the proper display which should be verified at each step.

Enter	Display
US/IMP switch to US	
LAND/NAUT switch to LAND	
F/2 switch to F	
C	Ø.
1ØØ	1ØØ.
÷	1ØØ.
81	81.
x	1.2345679
9	9.
-	11.111111
13	13.
A/O	13.
1	1.
A/O	1.
9	9.
+	2.ØØØØØØ MINUS indicator on
2	2.
=	Ø.ØØØØØØ
CO NV	Ø.ØØØØØØ
Ø (C^{O})	Ø.ØØØØØØ
·(F^{O})	32.
CO NV	32.
1 (FL OZ)	32.
2 (QT)	1.

Enter	Display
US/IMP switch to IMP	1.
CO NV	1.
2 (QT)	1.
1 (FL OZ)	40.
M	40.
- (M-1)	40.
CO NV	40.
4 (INCH)	40.
7 (MM)	1016.
M	1016.
2	1016.
+ (M+)	1016.
25.4	25.4
CO NV	25.4
CO NV (K)	25.4
M	25.4
= (MR)	1016.
CO NV	1016.
M (B)	1016.
A/O (A)	40.
÷	40.
M	40.
1	40.

Enter	Display	
= (MR)	40.	MINUS indicator on
=	1.	
CONV	1.	
= (MILE)	1.	MINUS indicator on
6 (YARD)	1760.	MINUS indicator on
LAND/NAUT switch to NAUT	1760.	
CONV	1760.	
= (MILE)	1760.	
5 (FEET)	10693963.	
CONV	10693963.	
C (LIT)	10693963.	MINUS indicator on
1 (FL OZ)	3.7.6.3.7.4.7.3.	OVF indicator, MINUS indicator on
C	3.7637473	MINUS indicator on
F/2 switch to 2	3.7637473	MINUS indicator on
=	0.09	
CONV	0.09	
x (OZ)	0.09	
+ (GM)	2.551457	
M	2.551457	
C (MC)	2.551457	
M	2.551457	
= (MR)	0.	

VI. TROUBLESHOOTING & PROBLEM ISOLATION

TEST EQUIPMENT

The following test equipment is required for the performance of the tests defined in the problem isolation section.

Instrument Type	Required Characteristics
Voltmeter	DVM 10M ohm = Zin 4-1/2 digit
Oscilloscope	Bandwidth - 10M Hz Dual Channel Vert. Sensitivity - 50 mv/cm Vert. Accuracy - ±3% Time Base, Sweep Range - 0.5 usec/cm to 100 ms/cm
Power Supply	Variable 0 - 10v I = 0.3A min

TROUBLESHOOTING TABLE

The following table defines the most common failure symptoms of the calculator and their probable causes. It is not intended to be all inclusive. A thorough review of the circuit descriptions (Section III), circuit schematic (Figure 12) and the tests defined in the problem isolation portion of this section for related symptoms will aid in diagnosing and repairing most failures encountered.

	Symptom	Possible Faults	Diagnosis and Repair
1.	Display does not light	a. Defective On/Off switch	See Section 1.
		b. Defective power supply Z1	
		c. Defective power-on reset circuit	
		d. Open or short on printed wiring board (PWB)	
		e. Defective MOS device	
		f. Defective CR1 diode	
		g. Defective battery clips	
		h. Defective or loose display	
		i. Discharged batteries	
		j. Defective power supply circuit	
2.	Dim Display	a. Low battery voltage	See Section 2.
		b. Defective power supply circuit	
		c. Open or short on PWB	
		d. Defective Digitron display	
		e. Defective filament power supply	
3.	Will not clear when initially turned on	a. Defective "power-on" reset circuit	See Section 3.
		b. Open or short on PWB	
		c. Defective MOS device	
4.	Random segments or decimal points missing from one or more digits	a. Defective Digitron display	See Section 4.

	Symptom	Possible Faults	Diagnosis and Repair
5.	Same segment missing from all digits	a. Defective MOS device b. Open or short on PWB c. Loose connector or Digitron display d. Defective Digitron display	See Section 5.
6.	Digits missing from display	a. Open or short on PWB b. Loose connector or Digitron display c. Defective Digitron display d. Defective MOS device	See Section 5.
7.	Display all 8's or random segments	a. Defective On/Off switch b. Defective power-on reset circuit c. Open or short on PWB d. Defective MOS device	See Section 6.
8.	One or more keys do not enter	a. Open or short on PWB b. Defective MOS device (strobe outputs) c. Defective keyboard or wiring d. Defective MOS device (keyboard return) e. Overflow condition exists but overflow indicator not lighted f. Defective keyboard resistors	See Section 7.
9.	Display will not clear	a. Defective power supply circuit b. Defective keyboard c. Open or short on PWB d. Defective MOS device	See Section 8.

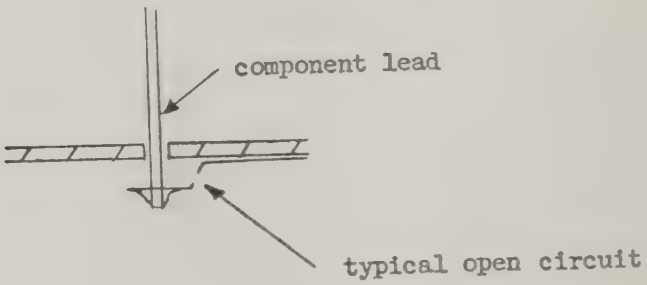
	Symptom	Possible Faults	Diagnosis and Repair
10.	Arithmetic operation not proper (wrong answer)	a. Open or short on PWB b. Defective MOS device c. Power supply incorrect (V_{DD}) d. Defective V_c resistor, R2 e. Defective V_c resistor, R2	See Section 12.
11.	Over or Neg indicator does not light	a. Open or short on PWB b. Defective LED c. Defective transistor or diode d. Defective MOS device	See Section 9 & 10.
12.	Over and Neg indicators both light when not commanded	a. Defective Q3 b. Short on PWB c. Defective MOS device	See Section 11.

PROBLEM ISOLATION

The following procedures are provided to assist in isolating the problems as determined by the diagnostic test in Section V. All tests, test points, and component designations refer to the Troubleshooting Schematic, Figure 12.

NOTE

Before starting any testing, after the calculator is disassembled, a thorough visual inspection should be performed. Possible problem areas: Cold solder joints (loose connections), broken wires and/or leads, shorts caused by wires being pierced by protruding leads on back of the printed wiring board, damaged components, loose display connector sockets/pins, damaged/bent battery terminal clips, broken/loose switch slider. An open circuit on the printed wiring board is sometimes difficult to locate. A typical open circuit is shown below.



1. Display does not light.

   A. Remove the batteries and bottom case (reference Figure 5).

   B. Apply 6.Ø ± Ø.1 volts dc to the adapter jack (J1). Connector shell is negative.

   C. Turn calculator "on".

      (1) If "Ø." does not appear in display, turn the calculator "off" and proceed to step D below.

      (2) If "Ø." does appear in display, check the battery terminals for contact with the batteries; and check wires from the battery terminals for breaks and/or loose connections.

   D. Observing polarity, apply 6.Ø ± Ø.1 volts dc to the battery terminals.

   E. Turn the calculator "on".

      (1) If "Ø." does not appear in display, turn the calculator "off" and proceed to step F below.

      (2) If "Ø." does appear in display, check CR1 and the adapter jack. Check wires from jack to batteries and ground clip.

   F. Disassemble the calculator to make the component side of the printed wiring board accessible (reference Figures 6 and 7).

   G. Apply 6.Ø ± Ø.1 volts dc to C2, noting the polarity per Figure 12.

      (1) If "Ø." does not appear in display, proceed to step H below.

      (2) If "Ø." does appear in display, check the On/Off switch (SW1). Check the wires from the battery terminals for breaks and/or loose connections.

   H. With 6 volts dc still supplied to C2, measure between +23.36 and +26.36 volts dc between the "2" and "4" (ground) test points on the printed wiring board. Then measure between +14.2 and +15.8 volts dc between the "2" (+) and "3" test points.

      (1) If both voltages are correct, proceed to step I below.

      (2) If either voltage is incorrect, check Q1, Q2, VR1, VR2, and Z1 and check the PWB for shorts or open circuits.

I. Verify filament circuit waveform (see Figure 12).

(1) If waveform is correct, proceed to step J below.

(2) If waveform is incorrect, check Q4, CR1Ø, CR11, R21, R22, and strobe waveform STRO (see Figure 13). If STRO is incorrect, proceed to step J below.

J. Check the strobe and segment waveforms per the schematic (Figure 12).

(1) If strobe and segment waveforms are correct, replace the display (DS1).

(2) If strobe and segment waveforms are incorrect, check R2. If R2 is good and there are no open or short circuits on its PWB circuit, replace MOS device (U1).

2. Dim display.

A. Remove battery access cover and, with the calculator "on", measure the battery voltage.

(1) If the voltage is 4 volts dc or greater, proceed to step B below.

(2) If the voltage is less than 4 volts dc, recharge the batteries if they are the rechargeable type or replace them if they are disposable.

B. Remove the bottom case (reference Figure 5).

C. Measure voltage between test points "2" and "4" (ground).

(1) If voltage is between +23.36 and +26.36 volts dc, proceed to step D below.

(2) If voltage is not between +23.36 and +26.36 volts dc, check VR1, VR2, Q1 and Z1.

D. Check filament voltage waveform per the schematic (Figure 12).

(1) If waveform is correct, check Q3, then proceed to step E.

(2) If waveform is incorrect, check Q4, CR1Ø, CR11, R21, R22, and strobe waveform STRØ (see Figure 13). If STRØ is incorrect, replace the MOS device (U1).

E. Remove and reinsert the display, making sure all pins are straight and seated in the connector.

(1) If display is bright (normal), inspect for loose connection.

(2) If the display is still dim, replace the display (DS1).

3. Calculator does not clear on initial turn on.

A. Disassemble the calculator to make the component side of the printed wiring board accessible (reference Figures 5, 6, and 7).

B. Check the rise time (t_r) of PØ at pin 11 of U1 and t_r of V_{DD} at test point "3", both with respect to test point "2" (MOS ground). t_r of PØ should be greater than t_r of VDD.

(1) If t_r of PØ is greater than t_r of V_{DD}, proceed to step C below.

(2) If t_r of PØ is less than t_r of V_{DD}, check C1, R1, R17, and CR2. Check for opens or shorts on printed wiring board.

C. Check CR2.

(1) If CR2 is good, replace MOS chip (U1).

(2) Replace CR2 if it is bad.

4. Segments missing from one or more digits.

A. Enter all 8's in display.

(1) If the same segment is missing from all digits, proceed to Section 5 below.

(2) If missing segments are random, replace the display (DS1).

5. Same segment missing from all digits or digits missing from display.

A. Disassemble the calculator to make the display accessible (reference Figures 5 and 6).

B. Remove display and visually inspect for damaged pins and connector sockets. Reinsert the display.

(1) If segments are still missing, proceed to step C below.

(2) If all segments are now visible, check for loose or bad connection which could cause intermittent problem.

C. Check segment or strobe* waveform of the display. Probe terminals on back of printed wiring board (reference Figure 12).

(1) If waveforms of display are incorrect, proceed to step D below.

(2) If waveforms at display are correct, replace the display (DS1).

D. Check segment or strobe* waveforms at the MOS device (U1).

(1) If waveforms are correct at the MOS device, check the PWB for "open" circuit.

(2) If waveform is not correct at the MOS device, check the PWB for "short" circuit. If PWB is all right, replace the MOS device (U1).

6. All 8's displayed or random segments.

A. Turn calculator "on" and "off" several times and observe display for intermittent clearing.

(1) If "Ø." does not appear in display, proceed to Section 3.

(2) If "Ø." does appear in display, check the On/Off switch (SW1). Replace keyboard assembly if switch is defective.

7. Keys do not enter.

A. Depress C key twice to clear calculator.

(1) If problem still exists, proceed to step B below.

(2) If problem is corrected by clearing, check overflow indicator, CR9, and related circuit.

B. Disassemble the calculator to make printed wiring board and keyboard terminals accessible (reference Figures 5, 6, and 7). Check wiring between printed wiring board and keyboard.

C. Apply 6.Ø ± Ø.1 volts dc to C2. Measure between +23.36 and +26.36 volts dc between the "2" and "4" (ground) test points on the printed wiring board. Then measure between +14.2 and +15.8 volts dc between the "2" (+) and "3" test points.

(1) If both voltages are correct, proceed to step D below.

(2) If either voltage is incorrect, check Q1, Q2, VR1, VR2, Z1 and check the PWB for shorted or open circuits.

*NOTE: In the case of missing segments, check the segment waveforms. When digits are missing from the display, check the strob waveforms.

D. Check strobe waveforms at the keyboard strobe terminals (see Figure 12).

(1) If waveforms are correct, proceed to step E below.

(2) If waveforms are not correct, proceed to step F below.

E. With the key depressed, check the strobe waveforms at the keyboard terminals KB1, KB2, KB3, and KB4. E (alternate) below may be performed.

(1) If waveforms are correct at the KB terminals, proceed to step G below.

(2) If waveforms are not correct, replace the keyboard.

E. (Alternate) Using the schematic, Figure 12, measure the resistance across each set of key contacts with the calculator turned off. Contact resistance should be less than 1ØØØ ohms and is usually near Ø ohm. Each key should be depressed several times in case intermittent defects are present or suspected.

(1) If keyboard operates properly, proceed to step G below.

(2) If keyboard does not operate properly, replace the keyboard.

F. Check strobe waveforms at the MOS chip (U1).

(1) If waveforms are correct, check printed wiring board for open circuit.

(2) If waveforms are not correct, check printed wiring board for "short". If printed wiring board is good, replace the MOS chip (U1).

G. Check resistors R3Ø, R31, R32, and R33 on the keyboard lines. Replace if defective. If resistors are good, check printed wiring board for open circuit. If printed wiring board is good, replace the MOS chip (U1).

8. Display will not clear.

A. Turn calculator "off" and "on" again and enter a number.

(1) If display clears, check the battery voltage.

(2) If display does not clear, proceed to step B below.

B. Disassemble the calculator to make the printed wiring board and keyboard terminals accessible (reference Figures 5, 6, 7, and 8).

C. Measure between +23.36 and +26.36 volts dc between the "2" and "4" (ground) test points on the printed wiring board. Then measure between +14.2 and +15.8 volts dc between the "2" (+) and "3" test points.

(1) If voltages are correct, perform section 7.

(2) If voltages are incorrect, check Z1, Q1, VR1, VR2, and Q2.

9. Overflow indicator does not light.

A. Disassemble the calculator to make the printed wiring board accessible (reference Figures 5, 6, and 7).

B. Enter -98765432 x 9 = into the calculator.

(1) If the Negative indicator turns "on", look for broken wire or lead at LED, CR9. If all right, proceed to step C below.

(2) If the Negative indicator does not turn "on", check the printed wiring board for a "short" in the Q3 base to MOS chip pin 37 circuit. Check Q3. If the board and Q3 are good, replace the MOS chip (U1).

C. Check Segment 6 and Strobe 8 waveforms for simultaneous presence at the MOS chip (pins 22 and 37).

(1) If both signals are present simultaneously at the MOS chip, proceed to step D below.

(2) If both signals are not present simultaneously, replace the MOS chip (U1).

D. Check Segment 6 waveform at Q6 base.

(1) If the waveform is correct, proceed to step E below.

(2) If the waveform is not correct, check R23 and CR4 and replace if defective. If both parts are good, check the printed wiring board for "open" or "short" circuit.

E. Verify that the Q6 collector saturates to approximately -5.5 volts.

(1) If Q6 collector does turn on, proceed to step F below.

(2) If Q6 collector does not turn on to -5.5 volts, proceed to step G below.

F. Check CR7 and R29.

(1) Replace CR7 and/or R29 if they are defective.

(2) If both CR7 and R29 are good, check the printed wiring board for "open" circuit. If the board is good, replace the LED, CR9.

G. Verify that approximately -6 volts is present at Q6 emitter when strobe 8 is on.

(1) If -6 volts is present, replace Q6.

(2) If -6 volts is not present, check Q3. Replace if defective.

10. Negative indicator does not light.

A. Disassemble the calculator to make the printed wiring board accessible (reference Figures 5, 6, and 7).

B. Enter -98765432 x 9 = into the calculator.

(1) If the Overflow indicator is "on", look for broken wire or lead at LED, CR8. If all right, proceed to step C below.

(2) If the Overflow light did not turn "on", check the printed wiring board for a "short" in the Q3 base to MOS chip pin 37 circuit. Check Q3. If the board and Q3 are good, replace the MOS chip (U1).

C. Check Segment 7 and Strobe 8 waveforms for simultaneous presence at the MOS chip (pins 26 and 37).

(1) If both signals are present simultaneously at the MOS chip, proceed to step D below.

(2) If both signals are not present simultaneously, replace the MOS chip (U1).

D. Check Segment 7 waveform at Q5 base.

(1) If the waveform is correct, proceed to step E below.

(2) If the waveform is not correct, check R24 and CR5 and replace if defective. If both parts are good, check the printed wiring board for "open" or "short" circuits.

E. Verify that the Q5 collector saturates to approximately -5.5 volts.

(1) If Q5 collector does turn on, proceed to step F below.

(2) If Q5 collector does not turn on to -5.5 volts, proceed to step G below.

F. Check CR6 and R28.

(1) Replace CR6 and/or R28 if they are defective.

(2) If both CR6 and R28 are good, check the printed wiring board for "open" circuits. If the board is good, replace the LED, CR8.

G. Verify that approximately -6 volts is present at Q5 emitter when strobe 8 is on.

(1) If -6 volts is present, replace Q5.

(2) If -6 volts is not present, check Q3. Replace if defective.

11. Overflow and Negative indicators both light when not commanded.

A. Press the clear key and enter random numbers.

(1) If numbers enter into display, proceed to step C below.

(2) If numbers do not enter, proceed to step B below.

B. Turn calculator on and off several times.

(1) If both indicators turn off, proceed to Section 7.

(2) If indicators turn on intermittently, proceed to Section 6.

C. Check strobe 8 waveform at pin 37 of U1.

(1) If waveform is correct, proceed to step D.

(2) If waveform is incorrect, check for shorts in PWB and check Q3. If they are good, replace MOS chip (U1).

D. Check strobe 8 waveform at base of Q3.

(1) If waveform is correct, replace Q3.

(2) If waveform is incorrect, check for opens between MOS device and Q3. Check R18 and replace if necessary.

12. Arithmetic operation not proper (wrong answer).

A. Disassemble the calculator to make printed wiring board and keyboard terminals accessible (reference Figures 5, 6, and 7). Check wiring between printed wiring board and keyboard.

B. Apply 6.Ø ± Ø.1 volts dc to C2. Measure between +23.36 and +26.36 volts dc between the "2" and "4" (ground) test points on the printed wiring board. Then measure between +14.2 and +15.8 volts dc between the "2" (+) and "3" test points.

(1) If both voltages are correct, check R2 and then check the V_c circuit on the PWB for shorted or open circuits.

(2) If either voltage is incorrect, check Q1, Q2, VR1, VR2, Z1 and check the PWB for shorted or open circuits.

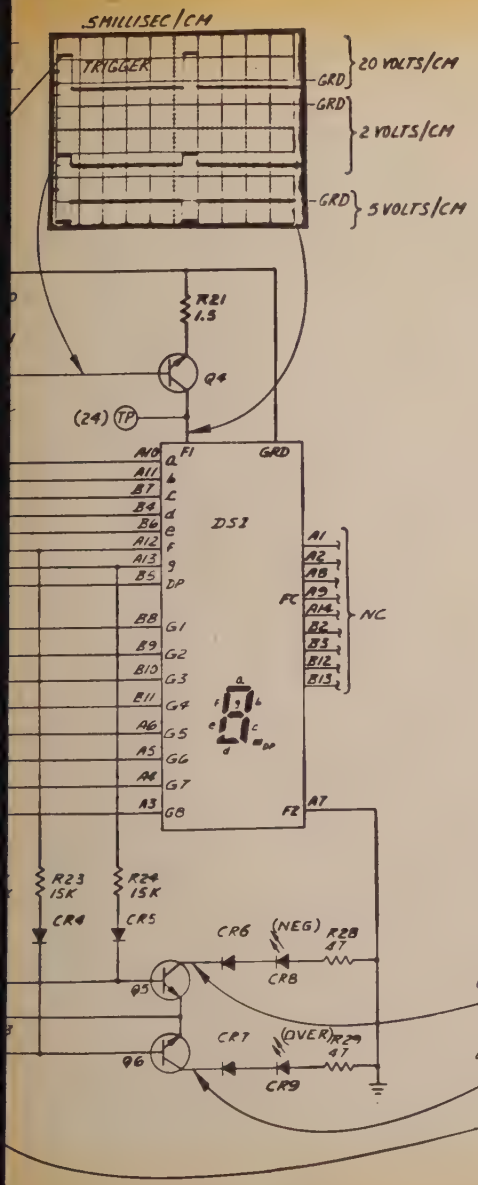
VII. DISASSEMBLY AND ASSEMBLY PROCEDURES

The calculator assembly consists of a top and bottom case and chassis assembly. The chassis assembly contains the printed wiring board assembly, keyboard assembly, the Digitron Display, and the battery compartment. The disassembly and assembly procedures are as follows:

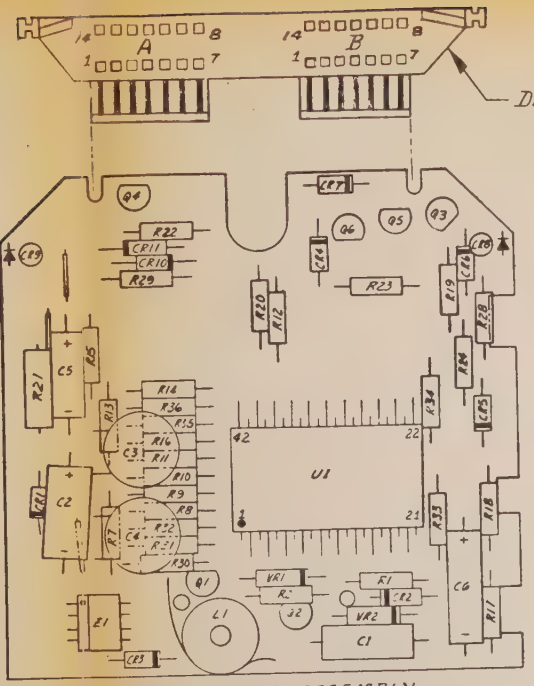
DISASSEMBLY PROCEDURES

Removal of Bottom Case

Remove battery cover by pulling the stand up, then sliding the cover out of the case and removing batteries.
Remove the screw visible at the bottom of the case.
Lift up on the bottom of case and slide forward.

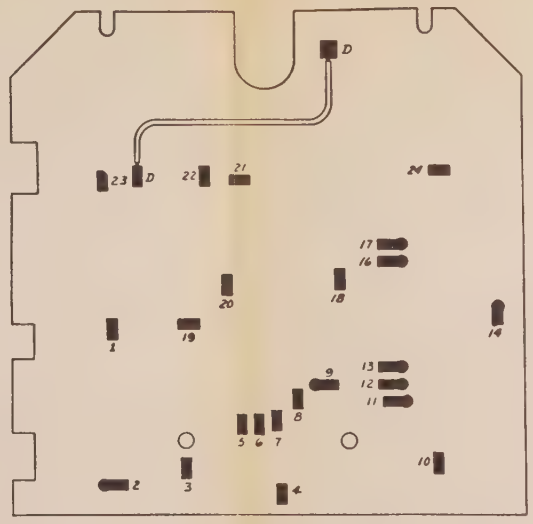


KEYBOARD CLEAR



DISPLAY CONNECTOR AND PIN ARRANGEMENT

PRINTED WIRING BOARD ASSEMBLY
(DISPLAY CONNECTOR OMITTED FOR CLARITY)



CIRCUIT SIDE OF BOARD SHOWING WIRING CONNECTION AND TEST POINTS

NOTE: USE STR8 TO TRIGGER SCOPE, .5 MILLISEC/CM AND 20 VOLTS/CM

ENTER, 1 MINUS 2 = NEG LIGHT (ON)

ENTER, 1 DIVIDED BY ZERO = OVER LIGHT (ON)

ENTER (8) ONES MINUS (8) TWOS TIMES (8) ONES = NEG AND OVER LIGHT (ON)

NEGATIVE & OVERFLOW WAVEFORMS

TROUBLE-SHOOTING AID, 8-DIGIT ELECTRONIC CONVERTER CALCULATOR (HAND-HELD)

Battery Cover

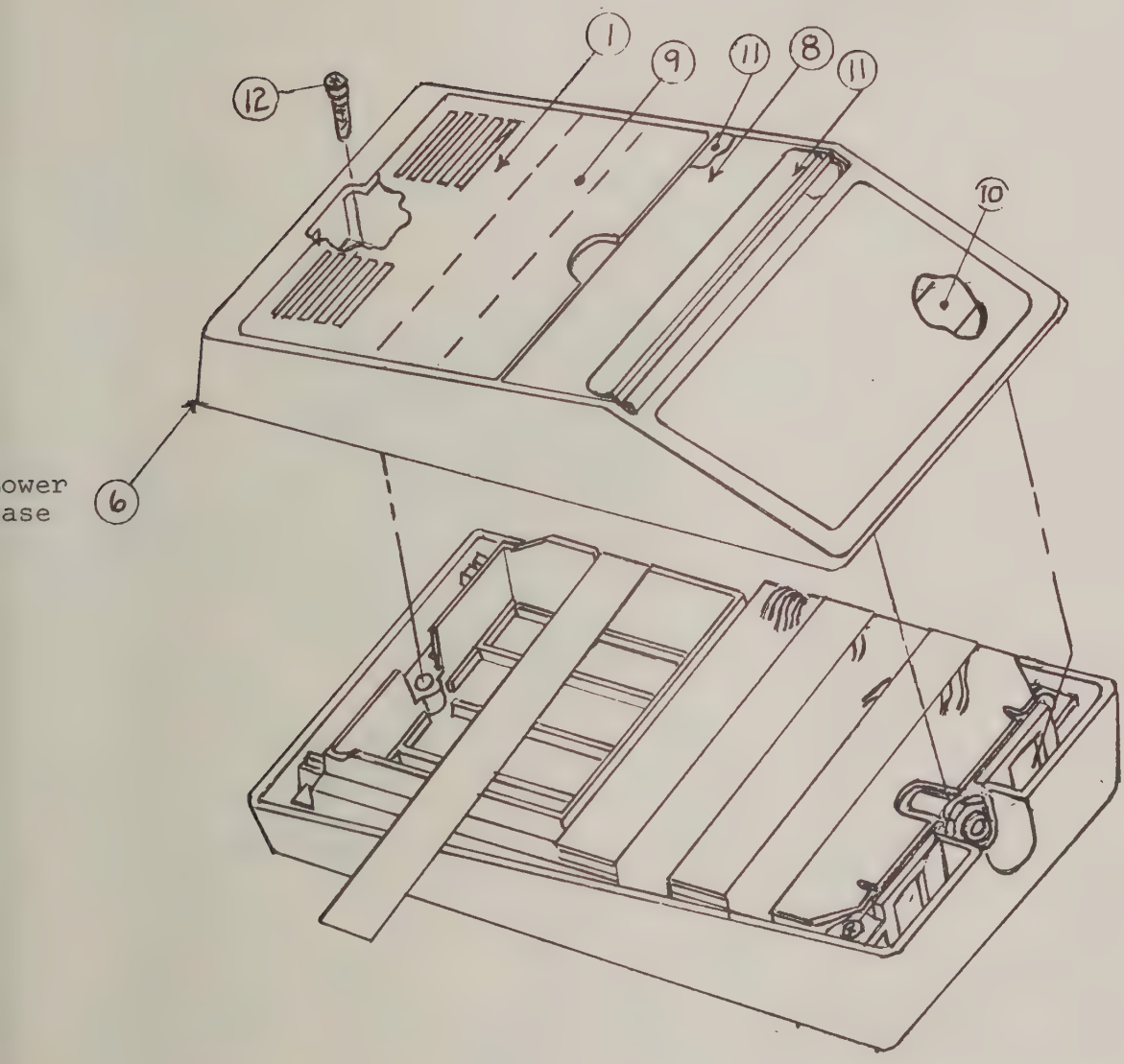


Figure 5

Removal of Chassis from Top Case

Remove the two screws from the top of the chassis.
Lift up and slide the chassis out of the case.

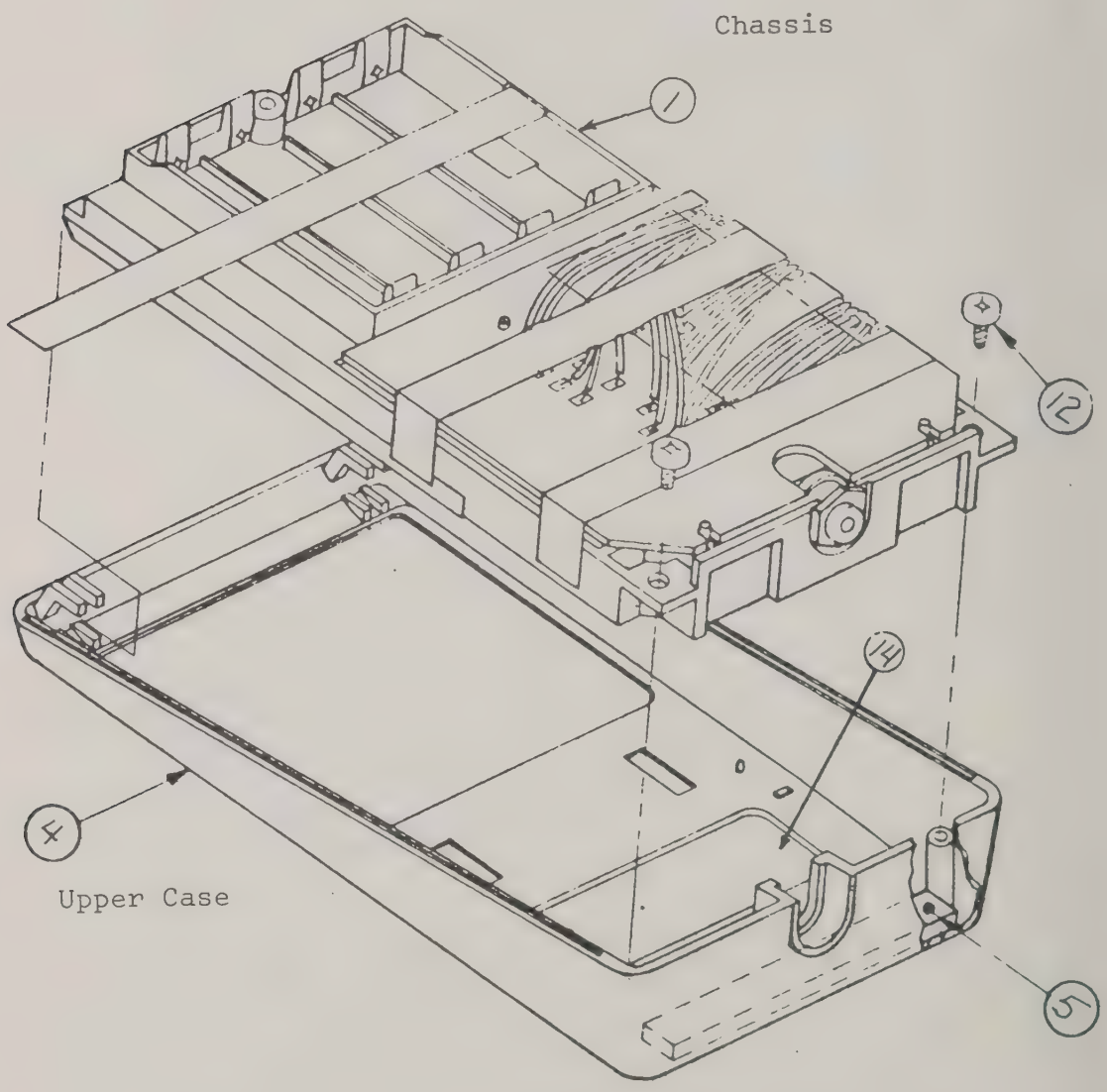


Figure 6

Removal of Printed Wiring Board (PWB)

Remove the masking tape strips from the PWB.
Lift the PWB from the locating pins.
Use a soldering iron to unsolder the attached wires (see procedure for removing leads and components, below).

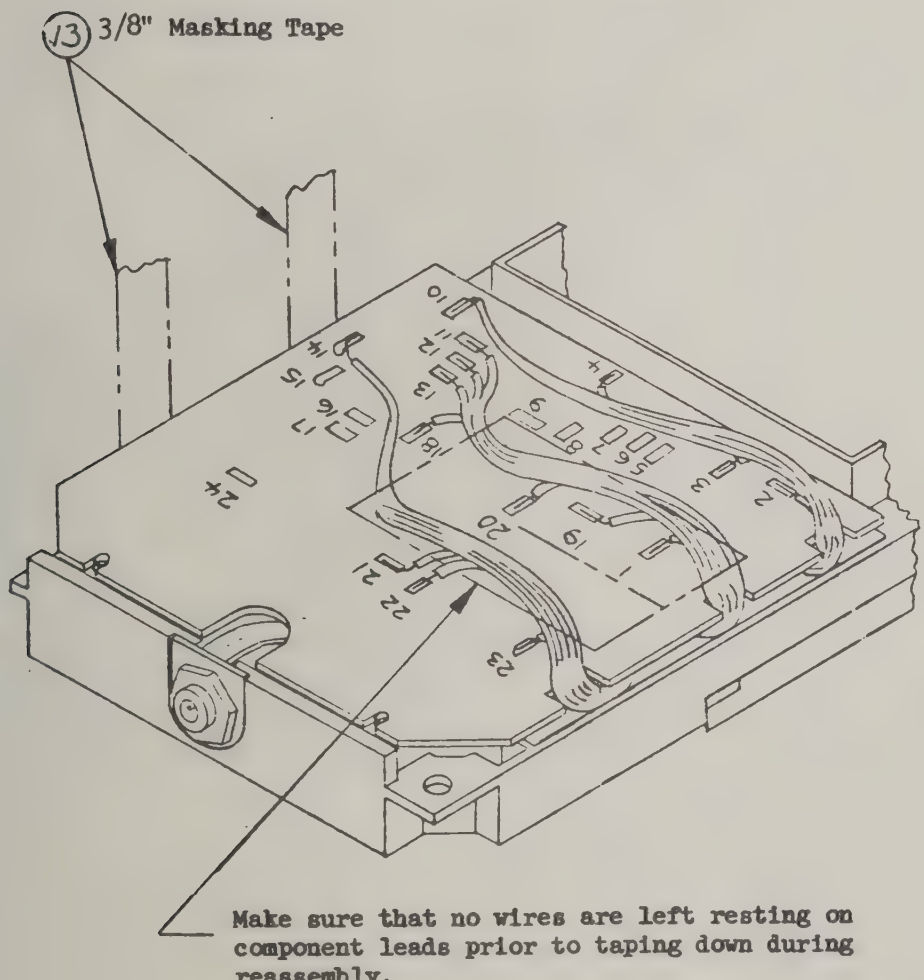


Figure 7

Keyboard Removal

To remove the keyboard from the chassis: Unsolder the wires at the keyboard strobe lines STR1, STR2, STR3, STR4, STR5 and the switches as shown in Figure 9. Remove the tape along each side and lift the keyboard out. Unsolder the remaining wires at the keyboard terminals KB1, KB2, KB3 and KB4. See Figure 10.

CAUTION: Do not exceed 5 seconds solder iron dwell time at switch terminals.

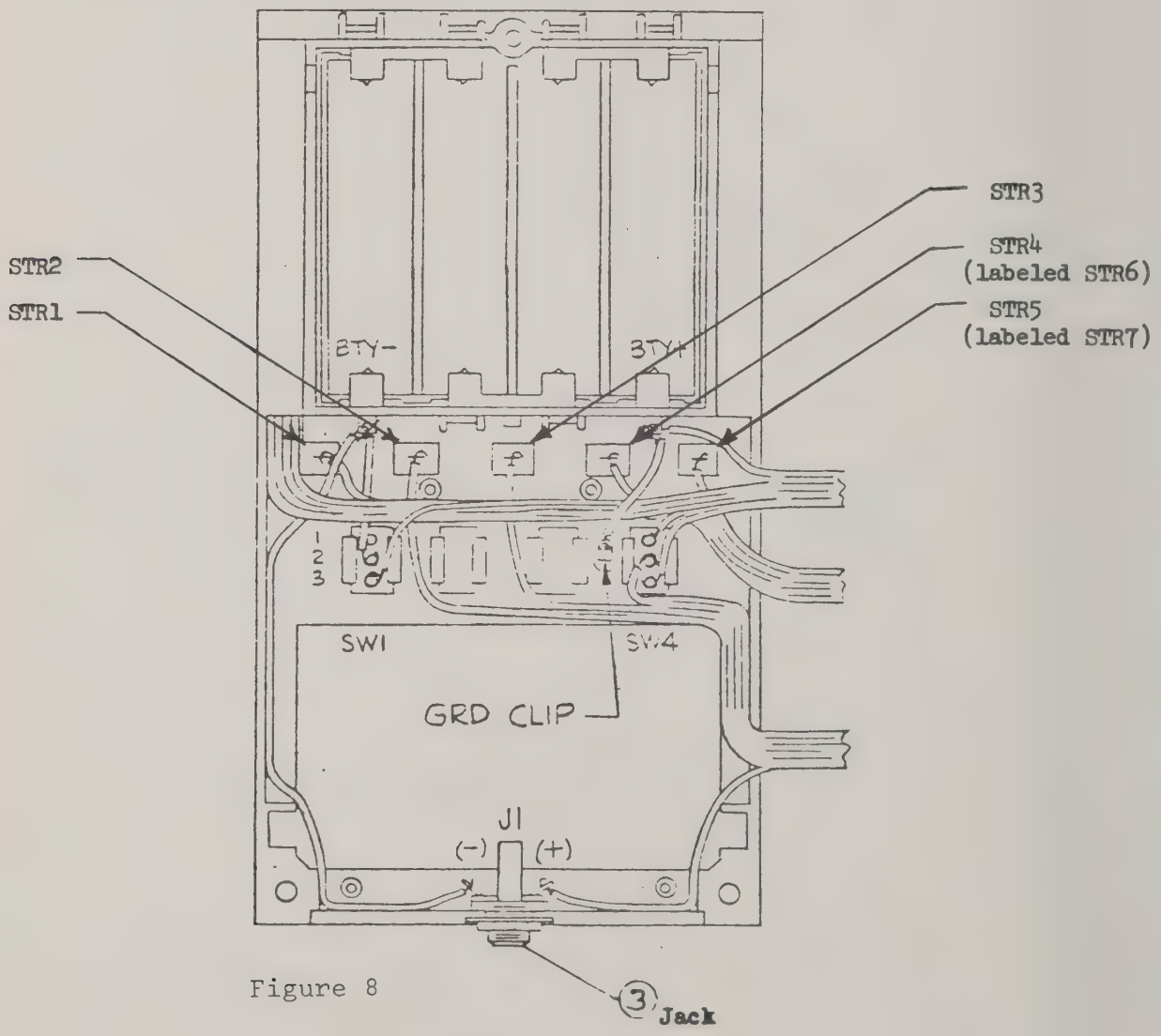


Figure 8

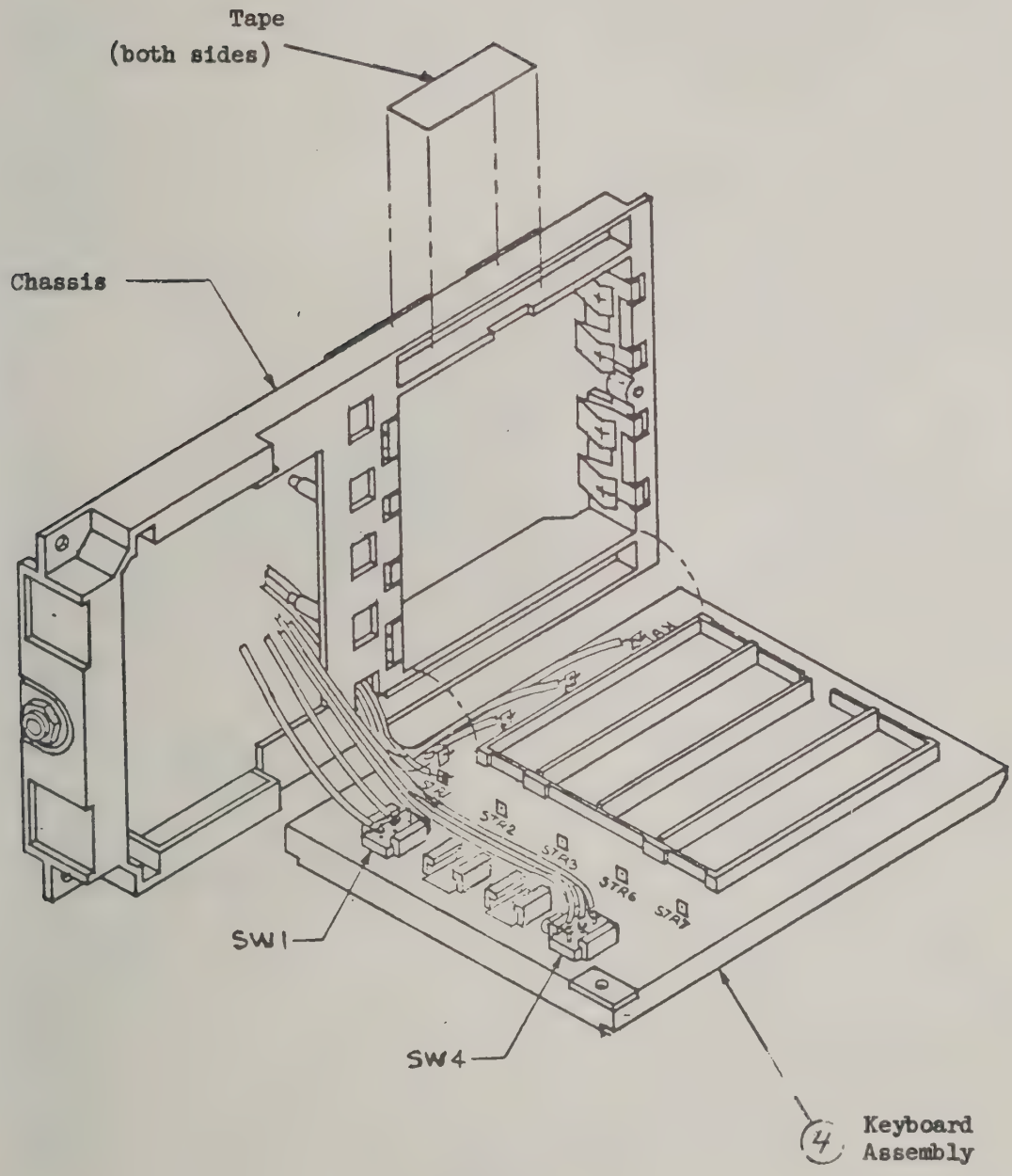
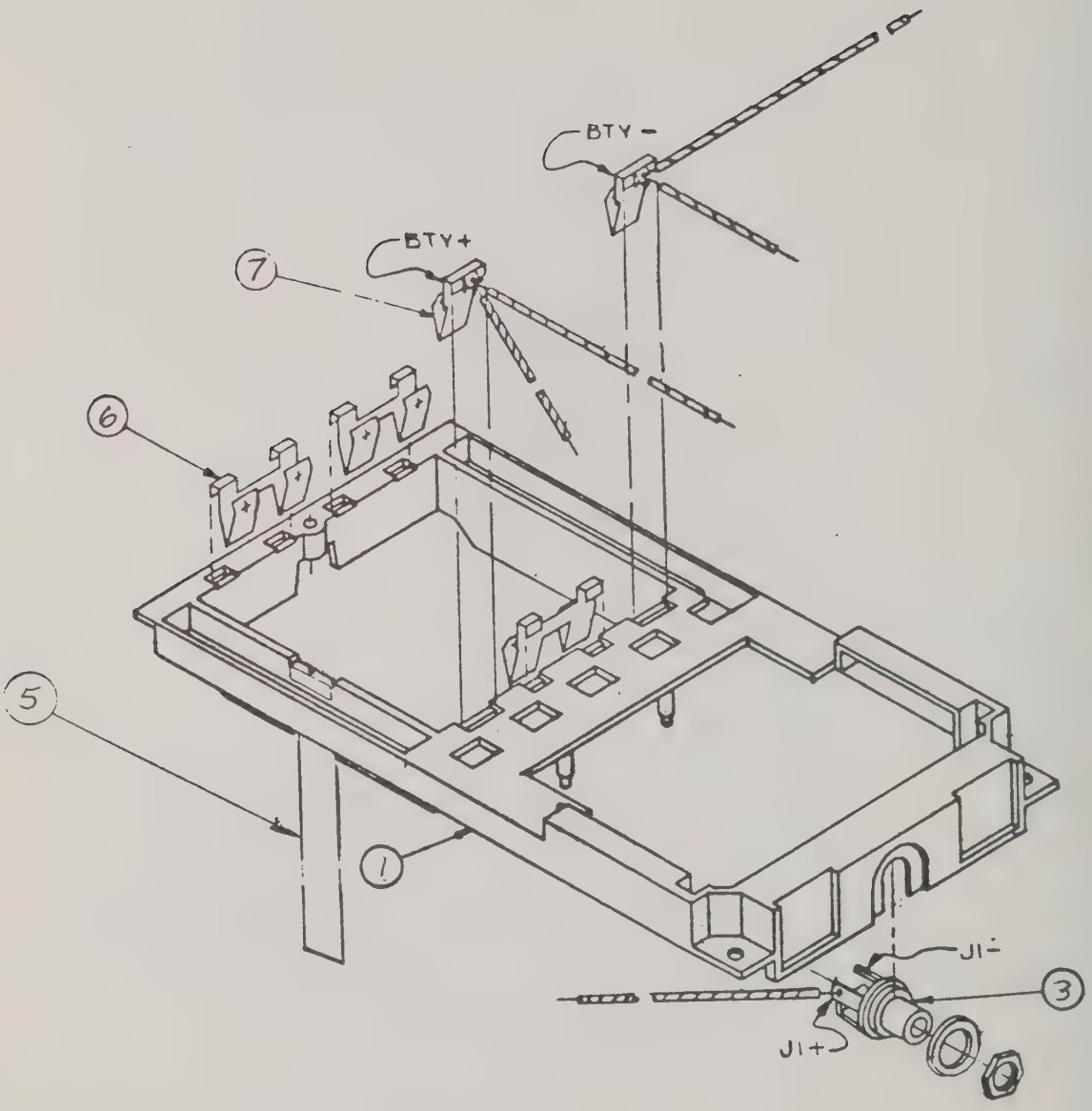


Figure 9



Battery Contacts & Jack Installation

Figure 10

ASSEMBLY PROCEDURES

To reassemble the calculator, reverse the removal procedures detailed above. In reconnecting the wires, follow the color-coded wire assignments as indicated by the wire list, Table 1.

Component Removal

Resistors, capacitors, diodes and transistors - Apply a hot soldering iron to the lead to be removed. Lift the lead off the printed circuit board with tweezers or similar tool as the solder melts. CAUTION: Excessive heat on the printed wiring board may damage circuitry.

MOS/LSI Device and Integrated Circuit (IC) Removal

MOS Device or IC - Remove the solder from each lead by using a desoldering device (Edsyn's Soldapullit, Ungar's Hot-Vac Printed Circuit Desoldering tool, Hexagon Electric Company's "Desolder Well", or similar devices) and lift the part off the printed circuit board.

Component Replacement

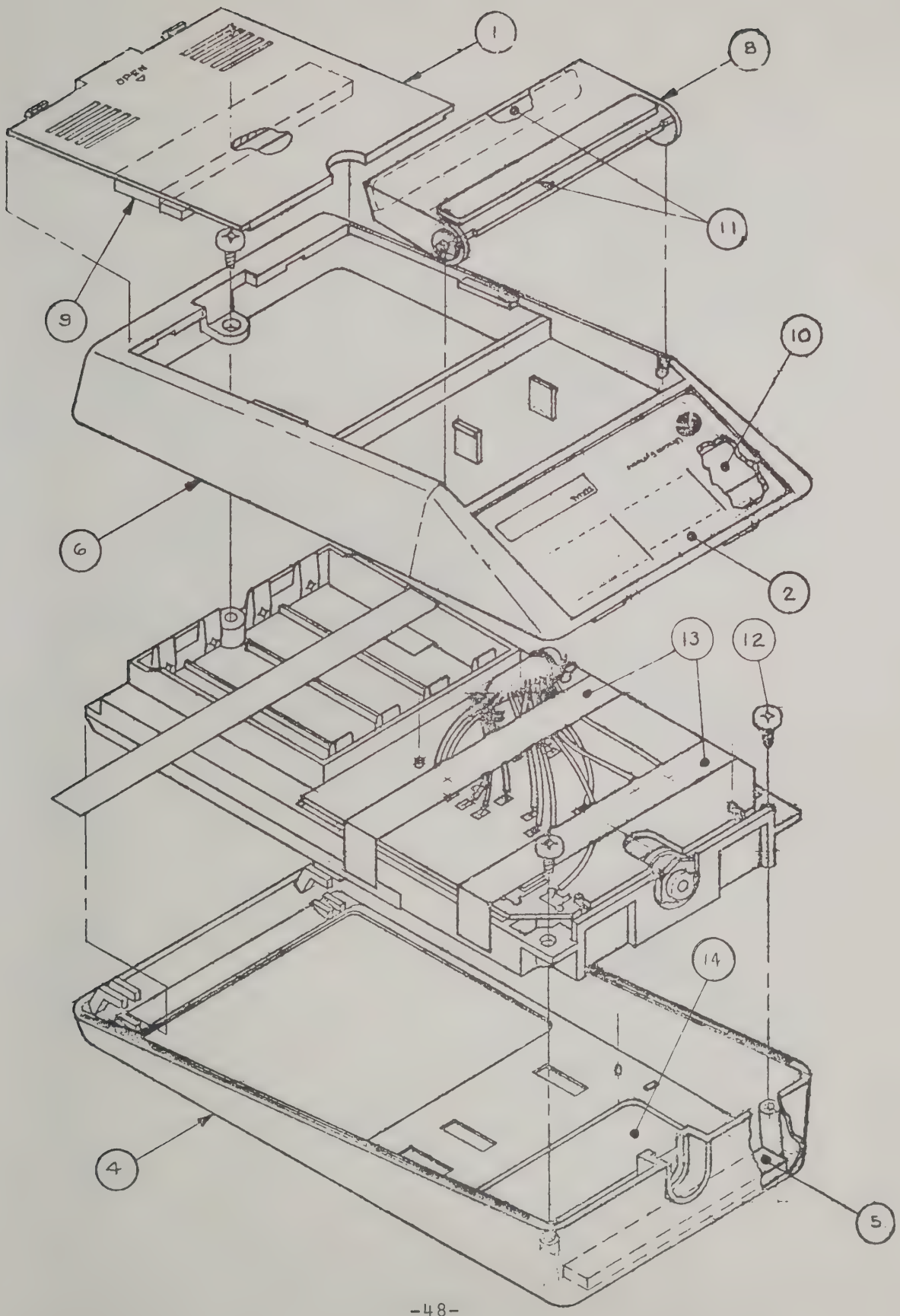
Resistors, capacitors, diodes and transistors - Bend and cut the leads of the replacement part to the same configuration as the part removed. In bending leads, always hold the lead between the body and the bend area with a pair of pliers to prevent cracking or breaking the part body. Solder coat the leads before inserting them in the holes in the printed wiring board. Solder the protruding end of the lead to the pad on the printed circuit board. Clip the lead flush with the solder. CAUTION: Be sure all replaced capacitors, diodes and transistors are installed correctly with regard to polarity.

MOS/LSI and IC Devices - The leads are preformed to fit the hole pattern in the printed wiring board (PWB). Be sure the pins are located correctly (the dot on the top of the case indicates pin number 1) as shown on the PWB layout (Figure 12). Solder the leads to the pads on the PWB and clip the protruding portion flush with the solder.

VIII. PARTS LISTS & SCHEMATIC

Parts List - Cover Assemblies

Reference	P/N	Description
1	8102-4032	Door, Battery
2	8102-4152	Nameplate
4	8102-4156	Case, Assy Upper
5	8102-4025	Cushion, Display
6	8102-4036	Case Assy, Lower
8	8102-4029	Stand, Flip Out
9	8102-4026	Cushion, Battery
10	8102-4027	Cushion, Chassis
11	8102-4028	Cushion, Stand
12	2800-0203	Screw, 4-40 x 1/4, P.H.
13	8102-4109	Tape, 3/8" wide
14	8102-4161	Window, Display
	8102-4110	Carrying Case (Not Shown)
	8102-4170	Battery, Nickel-Cadmium, 1.25V 4 required (Not Shown)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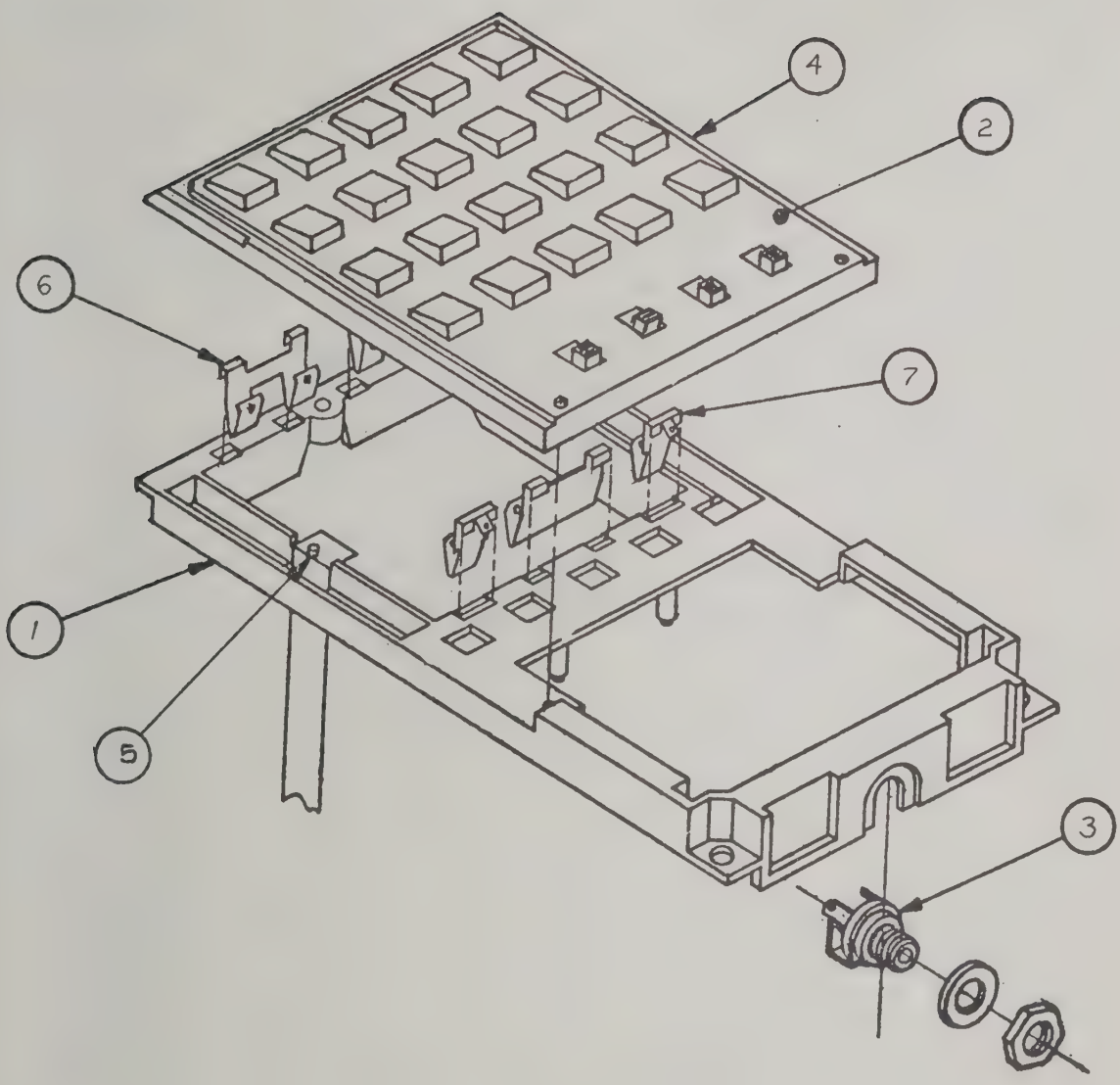
Parts List - Keyboard & Chassis

Reference	P/N	Description
1	8102-4157	Chassis
2	8102-4154	Plate, Decorative, Keyboard
3	2100-0056	Jack
4	8102-4163	Keyboard
5	8102-4022	Strap, Battery
6	2100-0058	Clip, Battery, Double
7	2100-0057	Clip, Battery, Single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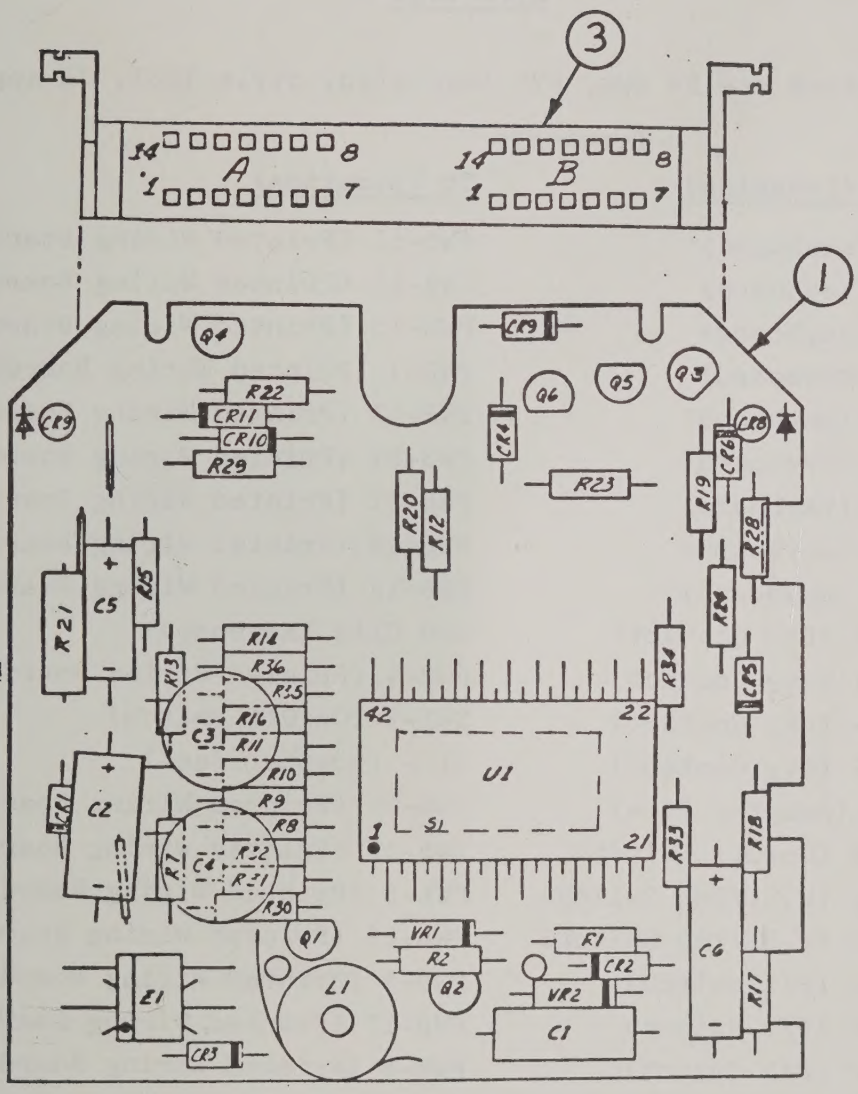
3

Parts List - PCB Logic Assy

Reference	P/N	Description
1	8102-4168	Printed Wire Board (No Components)
3	2100-0062	Connector Display Socket
4	5700-0011	Display (Not Shown)
Z1	8102-4166	IC Power Supply
L1	1502-0062	Choke 120 µf
U1	3130-0074	MOS/LSI
R28, 29	1408-0168	Resistor 47 ohm 1/4 watt
R7	1408-0162	Resistor 1K ohm 1/4 watt
R18, 22	1408-0165	Resistor 7.5K ohm 1/4 watt
R23, 24	1408-0167	Resistor 15K ohm 1/4 watt
R8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20	1408-0163	Resistor 100K ohm 1/4 watt
R2	1408-0164	Resistor 56K ohm 1/4 watt
R1	1408-0161	Resistor 200K ohm 1/4 watt
R30, 31, 32, 33, 34	1408-0169	Resistor 3.9K ohm 1/4 watt
R21	1408-0166	Resistor 1.5 ohm 1/2 watt
CR4, 5, 10, 11	1408-0050	Diode
CR1, 2, 3, 6, 7	1408-0051	Diode
CR8, 9	4801-0052	Diode LED
VR1	4801-0054	Diode Zener 10V
VR2	4801-0053	Diode Zener 16V
C3, 4	1501-0064	Capacitor .01 µf
C6	1501-0058	Capacitor 4.7 µf
C5	1501-0065	Capacitor 1 µf
C2	1501-0059	Capacitor 47 µf
C1	1501-0063	Capacitor .47 µf

Reference	P/N	Description
Q3, 5, 6	4800-0044	Transistor NPN
Q2	4800-0045	Transistor PNP
Q1, 4	4800-0046	Transistor NPN
S1	8102-4169	Shim, Cork



Printed Wiring Board Assembly
(Display Connector Omitted for Clarity)

Table I

Wire List

All wires are 28 AWG, PVC insulated, Style 1061, UL approved.

Terminals		
From (Location)	To (Location)	Color
KB1 (Keyboard)	PWB-11 (Printed Wiring Board)	Dk Green
KB2 (Keyboard)	PWB-12 (Printed Wiring Board)	Yellow
KB3 (Keyboard)	PWB-13 (Printed Wiring Board)	Red
KB4 (Keyboard)	PWB-1 (Printed Wiring Board)	Black
STR1 (Keyboard)	PWB-19 (Printed Wiring Board)	Gray
STR2 (Keyboard)	PWB-22 (Printed Wiring Board)	White
STR3 (Keyboard)	PWB-21 (Printed Wiring Board)	Orange
*STR4 (Keyboard)	PWB-2Ø (Printed Wiring Board)	Lt Purple
*STR5 (Keyboard)	PWB-18 (Printed Wiring Board)	Tan
BTY + (Bty Contact)	Grd Clip (Keyboard)	Lt Orange
BTY + (Bty Contact)	PWB-4 (Printed Wiring Board)	Lt Orange
BTY - (Bty Contact)	SW1-2 (On/Off Switch)	Blue
BTY - (Bty Contact)	J1 - (Adapter Jack)	Blue
J1 + (Adapter Jack)	PWB-14 (Printed Wiring Board)	Lt Pink
SW1-3 (On/Off Switch)	PWB-1Ø (Printed Wiring Board)	Lt Blue
SW2-1 (U.S./Imp Switch)	PWB-8 (Printed Wiring Board)	Dk Green
SW2-2 (U.S./Imp Switch)	PWB-16 (Printed Wiring Board)	Gray
SW3-1 (F/2 Switch)	PWB-9 (Printed Wiring Board)	Red
SW3-2 (F/2 Switch)	PWB-17 (Printed Wiring Board)	Lt Red
SW3-3 (F/2 Switch)	PWB-5 (Printed Wiring Board)	Tan
SW4-1 (Land/Naut Switch)	PWB-2 (Printed Wiring Board)	Black
SW4-2 (Land/Naut Switch)	PWB-23 (Printed Wiring Board)	Lt Green
SW4-3 (Land/Naut Switch)	PWB-3 (Printed Wiring Board)	Yellow

*STR4 and STR5 are labeled STR6 and STR7, respectively, on the keyboard.

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